HURRICANE WARNING!

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Hymenostilbe

CORDYCEPS

TORRUBIELLA

Pseudogibellula

How changed nomenclatural rules affect fungal entomopathogens

> **ABSTRACT:** The changes in the International Code of Nomenclature for fungi, algae and plants (a new name!) adopted at the 2011 International Botanical Congress brought a mix of the good, the bad, and the ugly. Most people will welcome the ability to publish descriptions and diagnoses of new taxa in English (or Latin), and to publish new taxa in a wide range of online rather than print media. Many people, however, may regard the elimination of dual nomenclature for the conidial and sexual states of individual pleomorphic fungi (e.g., the conidial states of ascomycetes in *Hypocreales*—the most common and best known entomopathogenic conidial genera) to be an unfortunate step backward forced by the adoption of a new standard referred to as 'One Fungus = One Name (1F=1N)

that will accept only a single generic name in the future for all connected conidial and sexual forms of fungal genera while suppressing all other linked genera; committees will have to choose which names to accept and to suppress, and will supposedly favor the earliest published applicable (sexual or conidial) generic name. These changes in the Code will have disruptive and destabilizing effects for several years, and will affect few fungi more severely than hypocrealean entomopathogens (e.g., Beauveria, Cordyceps, Isaria, Lecanicillium, Metarhizium, Nomuraea and many more). This poster explains the changes and suggests what might be the probable (if, for many of us, unwelcomed) decisions that will probably be reached for these fungi.

Cordyceps complex

Harposporium

Synnematium

Desmidiospora

Metarhiziun

Paecilomyces

Akanthomyces

Microhilum

Beauveria

Syngliocladia

Sorosporella Tolypocladium

Verticillium → *Lecanicillium*, Simplicillium, *Pochonia*, *Rotiferophthora*, etc.

CLAVICIPITACEAE -> CLAVICIPITACEAE, CORDYCIPITACEAE, OPHIOCORDYCIPITACEAE

CORDYCEPS → CORDYCEPS, ELAPHOCORDYCEPS, METACORDYCEPS, OPHIOCORDYCEPS

(before 2000)

The 2011 International Botanical Congress in Melbourne, Australia, adopted several extraordinary and far-reaching new nomenclatural rules affecting the organisms govern by the botanical Code. Some changes were warmly welcomed and overdue (Hawksworth 2011, Norvell et al. 2011):

- The Code is renamed as *International Code of Nomenclature for algae, fungi and plants (ICN)*
- New taxa can be described validly by diagnoses or descriptions in either in English or Latin
- New taxa can be published validly in electronic journals and books having an eISSN or eISBN
- ICN will not govern microsporidian nomenclature whether or not they are treated as fungi

The farthest-reaching change, however, was to replace the standard used to determine the names of organisms with multiple recognizable states: The existing dual nomenclature system allowed separate valid names for the conidial and sexual states of ascomycetes (or organ-genera of fossil plants). This standard was rejected and replaced by a new standard, most widely called One Fungus = One Name (1F=1N), that requires only one correct name to be applied to all states of a single organism. This new standard has unwelcomed and harsh implications for innumerable fungi and fossil plants, but the entomopathogenic conidial fungi in the order Hypocreales are severely affected.

How will 'correct' names by chosen? A series of committees (whose membership, structure, and guidelines for action are poorly understood) will make recommendations that can be validated, ultimately, only at an International Botanical Congress. **ONGOING PHYLOGENETICALLY BASED RECLASSIFICATIONS:**

What happens to names not accepted to be correct? The choices among competing names will operate primarily at the level of genera, and the fate of unaccepted alternate names remains uncertain at this moment. The votes in Melbourne involved language suggesting that these names would remain nomenclaturally valid but that their use would be 'suppressed' and that species from the suppressed genera would need to be transferred into the accepted correct genus. None of this, by the way, does anything to assure the short-term stability of organismal names!

How quickly will official decisions about correct and suppressed names be made? Nobody knows, but it will take several years to sort through the thousands of names being affected. Phylogenetic reclassification derived from Sung et al. (2007) Teleomorph-based genera in ALL CAPS

HYPOCRELLA → HYPOCRELLA, MOELLERIELLA, REGIOCRELLA, etc.

Paecilomyces → Isaria, Purpureocillium, etc.

What happens to those names that are not officially accepted as correct?

This may be the most important question to be asked, and it cannot yet be answered. The discussion and votes in Melbourne seemed to have agreed that these unaccepted (incorrect) alternate state names should be 'suppressed' (i.e., not used but still valid and available for use as needed according to taxonomic advances). The latest draft version of language for the official Code suggests something seriously and unacceptably different from a 'suppressed' status: The draft language says that these names should be treated 'as rejected' and would be unavailable for use unless or until restored to use by means of formal conservation (which can be a lengthy and troublesome process). This current draft language overrides and drastically modifies what many people believed they had voted for in Melbourne.

What names should we use until official choices are validated?

Again, official guidance is lacking! The best plan may be to understand the applicable rules that will guide these choices: There is no longer any official preference for names of teleomorphs over anamorphs, and the earliest published name should be the leading candidate. There might be reasoned exceptions for accepting a later name if that is for a state that is much more widely known, more common, and/or more economically important than the younger name. We can anticipate some of the most probable results (see the lowest, pink boxes at the right!) for hypocrealean entomopathogens.

What can be done if you don't like any of this?

Absolutely nothing for now! The new ICN to be released soon cannot be amended any sooner than the next International Botanical Congress (Beijing, 2017). No matter how bad the situation is or becomes, the new 1F=1N standard proposed and favored primarily by phylogeneticists (and passed after much heatedly political maneuvering) will probably *not* be rejected any time soon in favor of restoring the dual nomenclature standard. While this may be a thoroughly unhappy circumstance for many mycologists, invertebrate pathologists, and many more scientists in many disciplines, we have no option except to accept these changes, and to learn to live and to work with this new nomenclatural reality.

CLAVICIPITACEAE

METACORDYCEPS → Metarhizium, Nomuraea, Pochonia, Rotiferophthora,

HYPOCRELLA → Aschersonia **MOELLERIELLA** → aschersonia-like **ORBIOCRELLA** → aschersonia-like

sphacelia-like

REGIOCRELLA → aschersonia-like or

SAMUELSIA → aschersonia-like

CORDYCEPS > Beauveria, Isaria, Lecanicillium, Evlachovaea/Mariannaea-like, Microhilum, Simplicillium

CORDYCIPITACEAE

TORRUBIELLA → Akanthomyces, Gibellula,

Granulomanus, Pseudogibellula **ASCOPOLYPORUS** → aschersonia-like

CONOIDEOCRELLA → aschersonia-like

OPHIOCORDYCIPITACEAE

ELAPHOCORDYCEPS → Tolypocladium, verticillium-like **OPHIOCORDYCEPS** → Hirsutella, Hymenostilbe, Paraisaria, Sorosporella,

Syngliocladium

AFTER ADOPTION OF 1 FUNGUS = 1 NAME STANDARD (2012 and later) Teleomorph-based genera in ALL CAPS

NO formal choices of correct generic names have been made official.

CLAVICIPITACEAE

Metarhizium Sorokin (1879)

suppressed: METACORDYCEPS Sung et al. (2007), Nomuraea, Pochonia, Rotiferophthora

Aschersonia Montagne (1848)

suppressed: HYPOCRELLA Saccardo (1878) **MOELLERIELLA ORBIOCRELLA**

REGIOCRELLA **SAMUELSIA**

CORDYCIPITACEAE

CORDYCEPS Fries (1824)

suppressed: Beauveria, Isaria, Lecanicillium, Evlachovaea, Microhilum, Simplicillium

TORRUBIELLA Boudier (1885)

suppressed: Akanthomyces, Gibellula,

Granulomanus, Pseudogibellula

ASCOPOLYPORUS CONOIDEOCRELLA

OPHIOCORDYCIPITACEAE

? ELAPHOCORDYCEPS Sung et al. (2007) suppressed: Tolypocladium Gams (1971)

? OPHIOCORDYCEPS Petch (1931)

suppressed: Hirsutella Patouillard (1892←problem?), Hymenostilbe, Paraisaria, Sorosporella, Syngliocladium

The topmost chart (Cordyceps complex) provides a reminder of the majority of taxonomic links between conidial and sexual states as they were understood to exist for the great majority of clavicipitoid fungal entomopathogens in the order *Hypocreales* (Sordariomycetes) before the start of the gene-based phylogenetic reclassifications that began to appear in print (beginning in about 2000; green boxes). In all of the boxes above, the names of families and of teleomorphic (sexual) genera are in all capital letters; the associated anamorphic (conidial) genera are upper/lower case.

The first DNA sequence-based phylogenetic reclassifications of clavicipitoid entomopathogens revised Verticillium section Prostrata (Gams 1971) and Paecilomyces section Isarioidea (Samson 1974) out of existence, and were soon followed by the vastly complex reclassification of Clavicipitaceae and Cordyceps into three families and several genera (green boxes). The 'new nomenclature' dictated by 1F=1N (whether it is a dream or a nightmare, in the red and pink boxes) will not become an official reality for at least another couple of years.

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